Dielectric Transduction of NEMS

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Kaitlin Howell[1] and Luis Guillermo Villanueva[1]

1. EPFL - School of Engineering – Institute of Mechanical Engineering – Advanced NEMS Lab
Contact: Kaitlin Howell, kaitlin.howell@epfl.ch

Abstract

We report on a four-mask process flow for creating resonant NanoElectroMechanical Systems (NEMS) based on dielectric transduction. Current transduction mechanisms for NEMS include piezoelectricity [1], flexoelectricity [2] and dielectric force [3]. While piezoelectricity gives the highest electromechanical efficiency in, NEMS using flexoelectricity and dielectric force are interesting alternatives with a larger range of possible active materials and potentially simpler fabrication. In this four-mask process flow, doubly-clamped beams and cantilevers are patterned and released from the substrate. The beams are built of molybdenum (Mo) and halfnium oxide (HfO2) (Fig. 1).

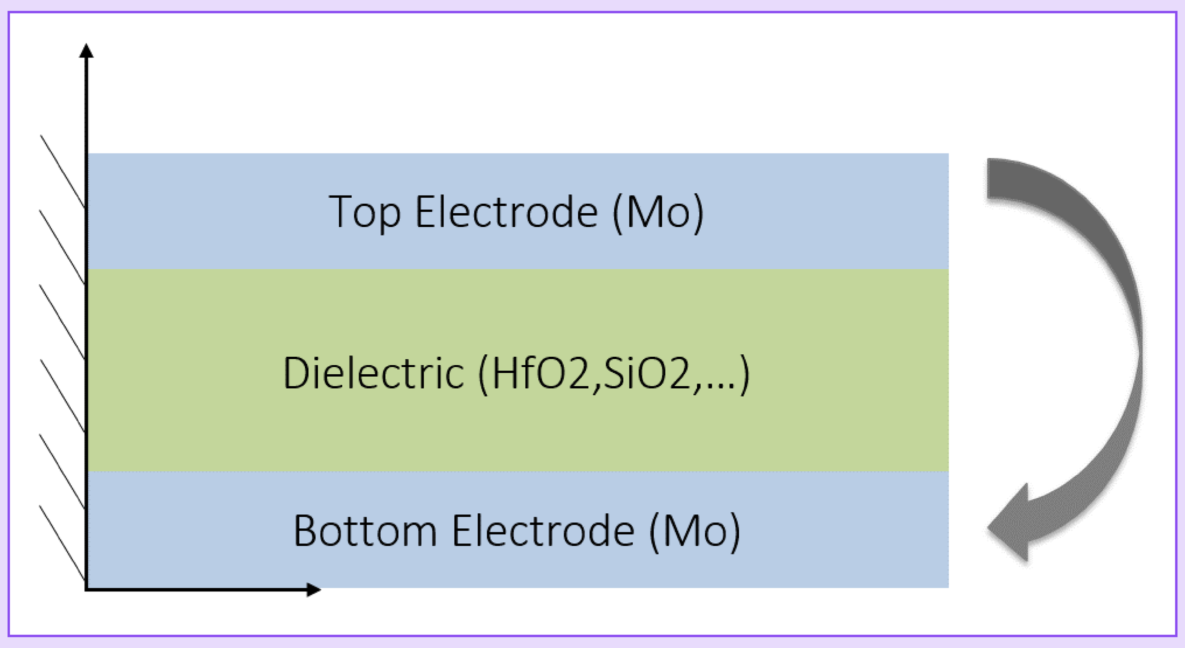
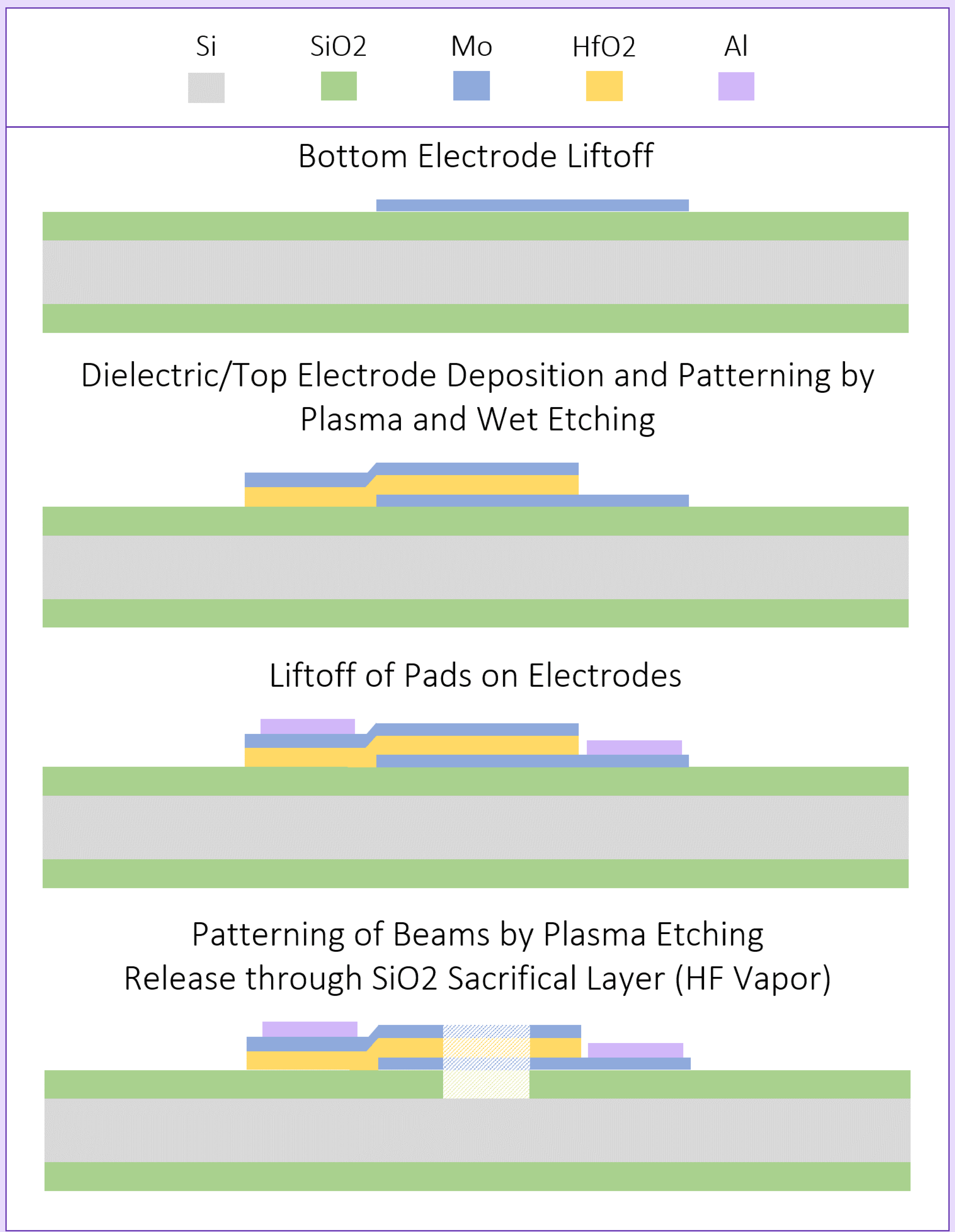


Fig.1: Cross section of fabricated beams, consisting of a dielectric material sandwiched between electrodes.

Process Flow



Fabrication Results

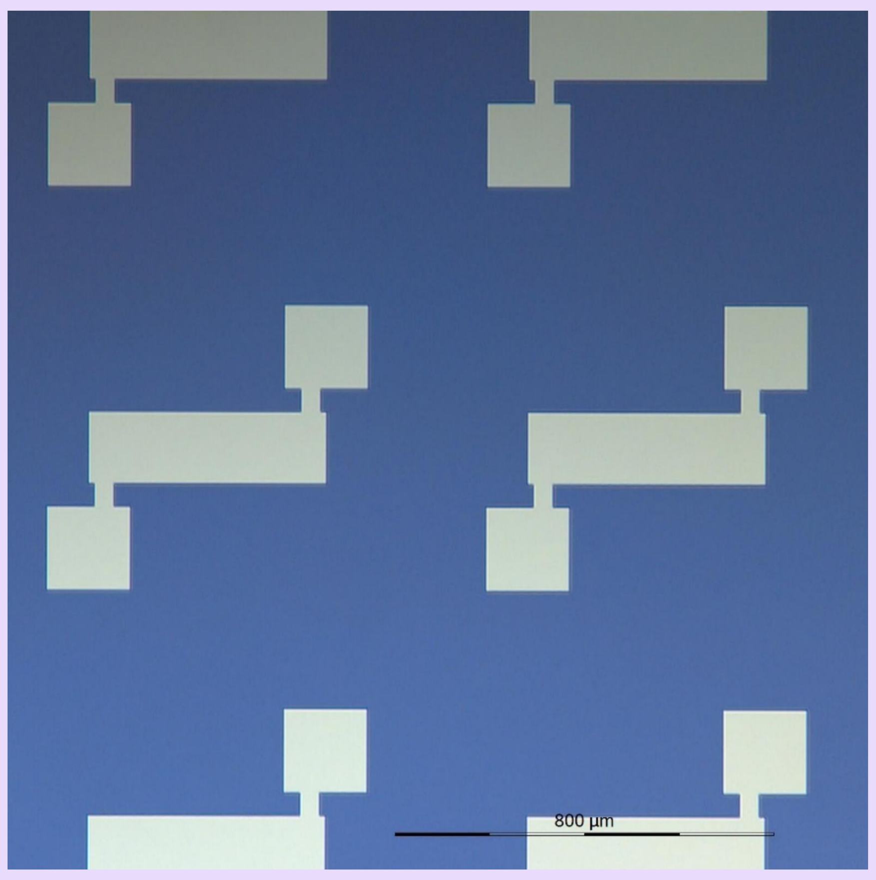


Fig. 2: Liftoff of Mo deposited by DC sputtering

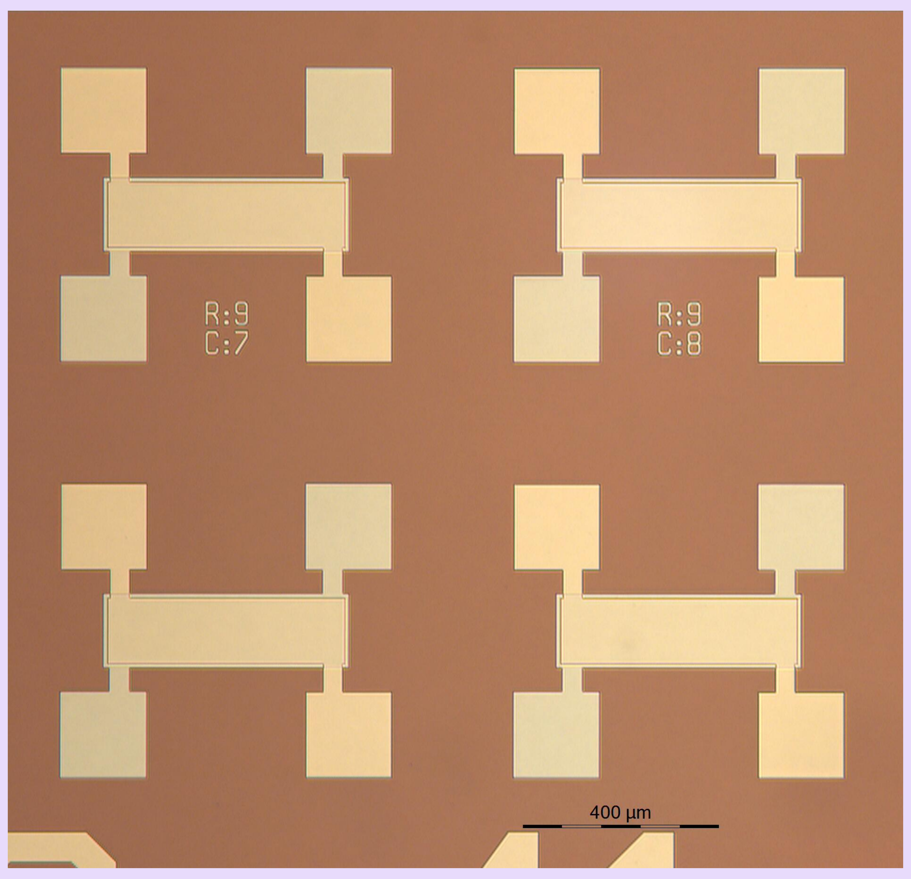


Fig. 3: Patterned Mo and HfO2 by plasma and wet etching, respectively

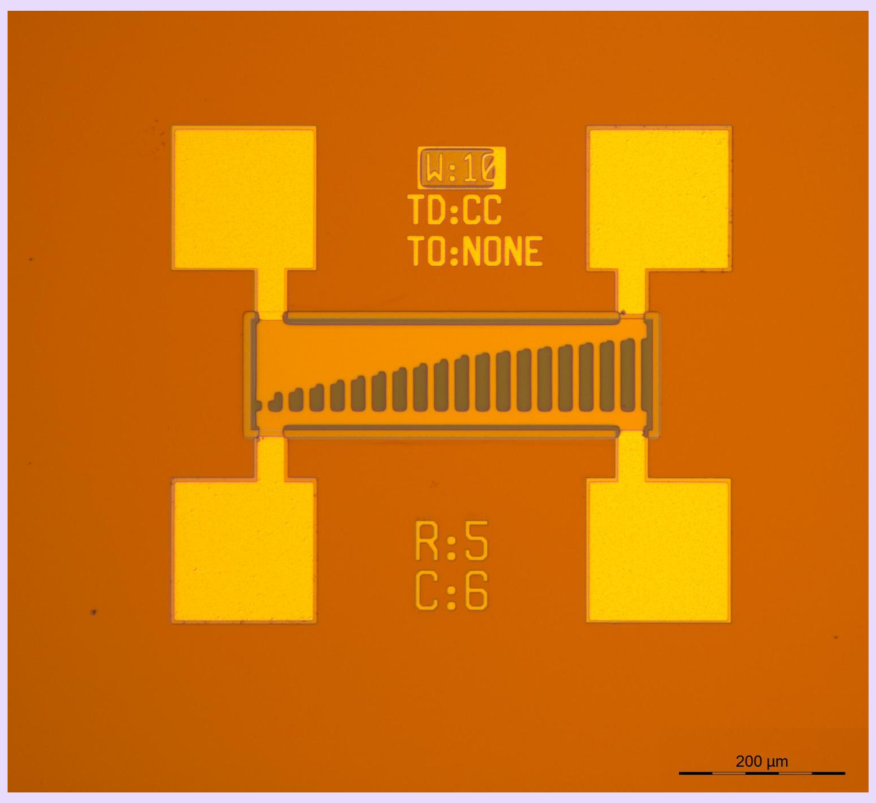


Fig. 4: Patterned doubly-clamped beams by plasma etching

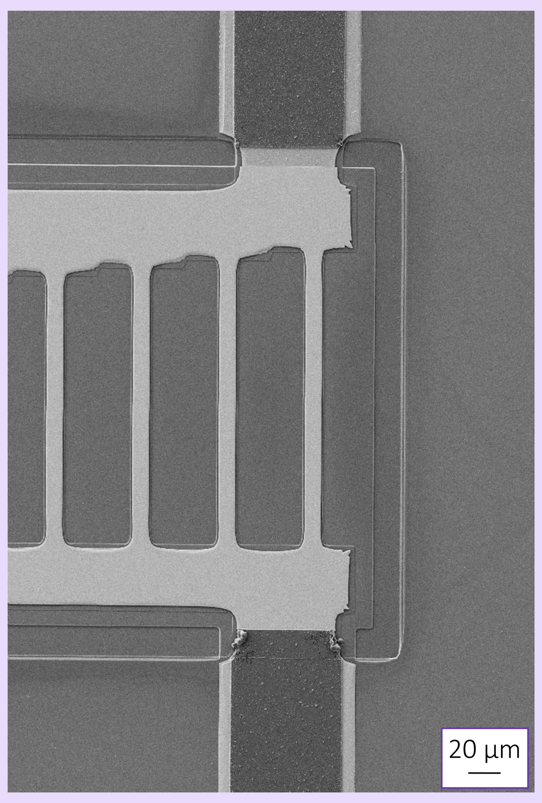


Fig.5: Doubly-clamped beams before release by vapor HF.

Fabrication Issues

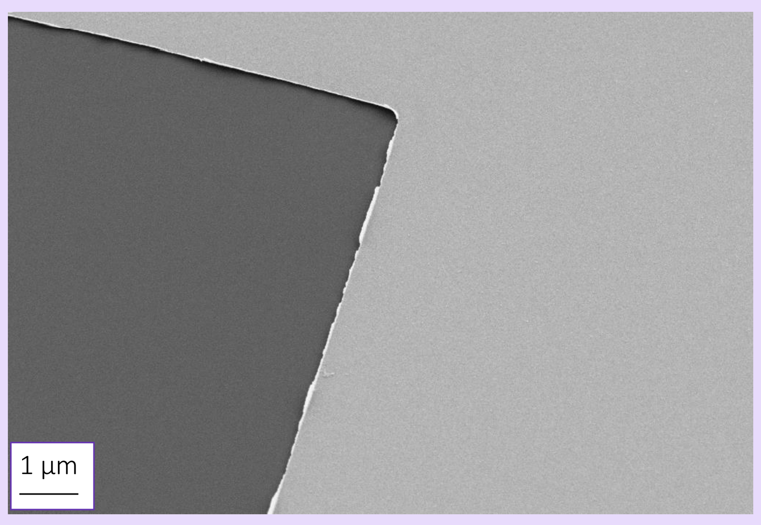


Fig. 6: Fencing on Mo electrode edges after liftoff. Potential Solutions: Ultrasound or use evaporation

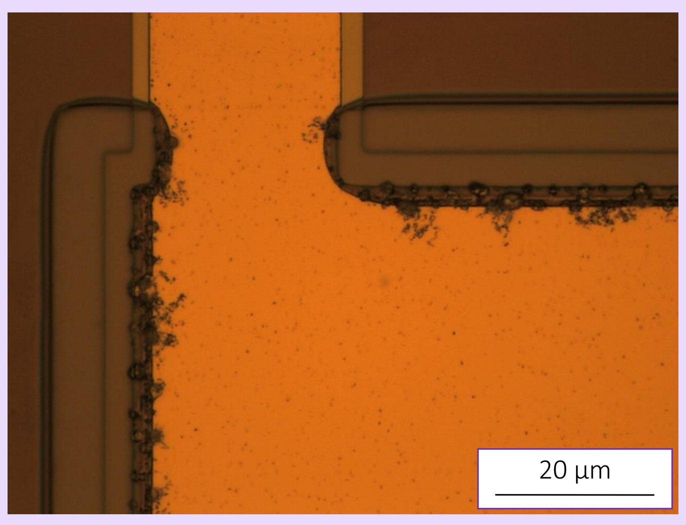


Fig. 7: Attack at edges of Al pad during plasma etching. Potential Solutions: Change etch chemistry or to more resistant metal

Conclusions

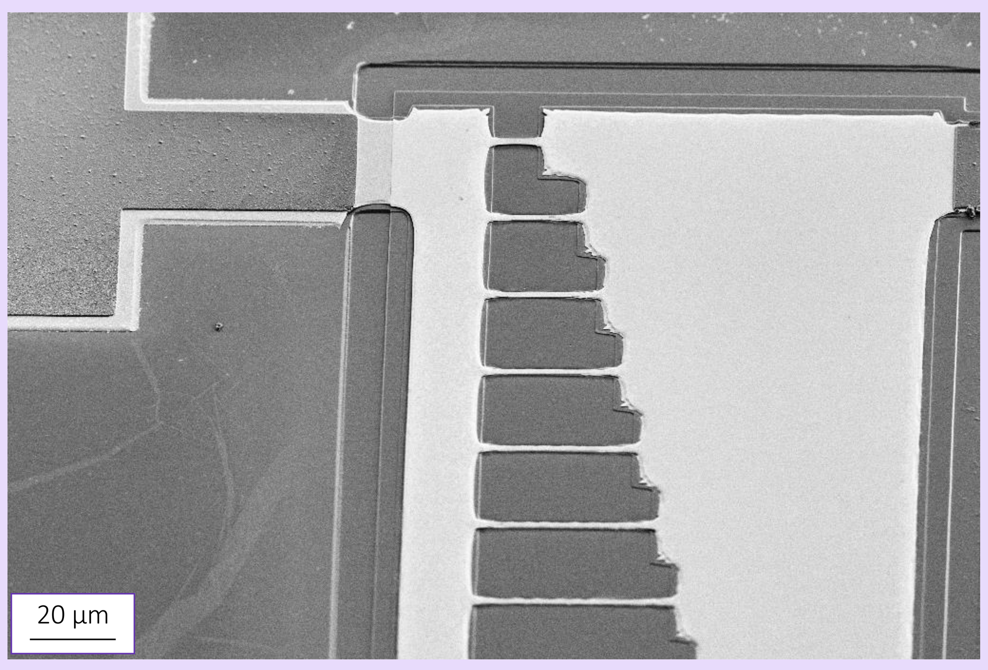


Fig. 8: Released cantilevers after vapor HF etching to remove sacrificial SiO2 layer

- Arrays of doubly-clamped beams and cantilevers were fabricated, consisting of Mo/HfO2/Mo.
- Future challenges: control residues, attack of aluminum and stiction.
- Beams will be qualified by conduction and deflection measurements.

References
[1] S. Schmid, L. G. Villanueva, and M. L. Roukes, "Fundamentals of nanomechanical resonators," *Fundam. Nanomechanical Reson.*, pp. 1–175, 2016.
[2] U. K. Bhaskar *et al.*, "A flexoelectric microelectromechanical system on silicon," *Nat. Nanotechnol.*, vol. 11, no. 3, pp. 263–266, 2015.
[3] C. Fuinel, F. Mathieu, and B. Legrand, "Driving and Sensing M/NEMS Flexural Vibration Using Dielectric Transduction," *Proceedings*, vol. 1, no. 4, p. 300, 2017.

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